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What is the longitudinal profile of impairments and can we predict difficulty caring for the profoundly-affected arm in the first year post-stroke?

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What is the longitudinal profile of impairments and can we predict difficulty caring for the profoundly-affected arm in the first year post-stroke?

Abstract

Objective: To establish the longitudinal profile of impairments of body functions and activity limitations of the arm, and evaluate potential predictors of difficulty caring for the profoundly-affected arm post-stroke.

Design: Prospective cohort study.

Setting: Three UK stroke services.

Participants: People unlikely to regain functional use of the arm (N=155) were recruited at 2-4 weeks post-stroke, and followed up at 3, 6 and 12 months. Potential predictors at baseline were hypertonicity, pain, motor control, mood, sensation/perception, age and stroke severity.

Interventions: NA

Main Outcome Measures: Difficulty caring for the arm (LASIS), pain, hypertonicity, range of movement, arm function and skin integrity. Multi-variable linear regression identified the best fitting model for predicting LASIS at 12 months.

Results: One hundred and ten participants (71%) were reviewed at one year. There was a large variation in the profile of arm functions and activity limitations. Inability or severe difficulty caring for the arm affected 29% of participants. Hypertonicity developed in 77%, with severe hypertonicity present in 25%. Pain was reported by 65%, 94% developed shoulder contracture and 6% had macerated skin. Difficulty caring for the arm increased with age, greater level of hypertonicity and stroke classification; collectively these factors accounted for 33% of the variance in LASIS.

Conclusions: At one year post-stroke, there was a high incidence of impairments of body functions and activity limitations in people with a profoundly-affected arm. Individual

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profiles were very variable and although some pre-disposing factors have been identified, it remains difficult to predict who is at greatest risk.

Key words: stroke, upper limb, spasticity, pain, contracture

List of abbreviations:

HAEM – Haemorrhage stroke

LACS lacunar stroke on Oxford classification

LASIS Leeds Arm Spasticity Impact Scale

MAL-14 Motor Activity log

MMAS Modified modified Ashworth Scale

PACS – Partial anterior circulation stroke on Oxford classification

POCS – Posterior circulation ischaemic stroke on Oxford classification

Q1, Q3 First quartile and third quartile of the inter quartile range

TACS total anterior circulation stroke on Oxford classification

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Three quarters of people with stroke will experience arm weakness, and 62% of these will not recover dexterity at six months[1]. For the purposes of this research, the term 'profoundly affected arm' is used to describe the situation where a stroke survivor has no movement in the affected arm or when movement is not functionally useful[2]. While current physical therapies in stroke rehabilitation are based predominantly on exercise and task-specific training[3,4], additional therapy and practice of tasks does not improve active function in those with the most significant weakness[5]. Hence for those most unlikely to regain active function, a focus on managing activity limitations and avoiding secondary complications may be more appropriate. This approach involves maintaining the ability to care for the arm including tasks such as hand-washing and nail-cutting (i.e. passive function activities[6] which may be conducted by the person themselves or their carer).

Previous research shows that hypertonicity is present as early as one week post-stroke[7] and affects up to 47% of survivors[8]. Pain can also occur within one week[9] with an incidence up to 49%[10]. Contracture is apparent by two weeks and affects 50%[11]. Previously reported predictors of hypertonicity include reduced motor control[7,8], and increased stroke severity[8,12]. The most common predictors of pain are reduced sensation[13,14], and weakness[13]. The significance of depression is not clear, with some studies identifying a positive link with pain[15], and others discounting this[8]. Contracture is most frequently predicted by weakness[16,17]. However, this previous research is limited as all of these studies have been conducted on general populations of stroke survivors and not targeted at those with the most significant weakness. Furthermore, none of these previous studies has evaluated the profile or potential predictors of difficulty caring for the arm after stroke in a systematic way[2].

Despite the high proportion of people with a profoundly-affected arm post-stroke (62%[1]), there is currently no targeted research on (1) the longitudinal profile of activity limitation in caring for the arm, (2) the proportion of people who develop associated impairments of body

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functions and (3) the relationship between initial clinical findings and subsequent difficulty caring for the arm. The aim of this study was to establish the longitudinal profile of impairment of body functions and activity limitation in people with a profoundly-affected arm, and evaluate potential predictors of difficulty caring for the arm, in the first year post-stroke.

Methods

Participants

In a prospective, longitudinal study, all adult patients with first or subsequent stroke admitted to three stroke units in the UK over 30 months from September 2011, and still under the care of the stroke team at 2 weeks post-stroke, were screened for inclusion. Criteria included stroke within the past 2-4 weeks and a Fugl-Meyer upper extremity score of equal to or less than 11 points at 2 weeks, or 15 points at 3 weeks, or 19 points at 4 weeks post-stroke. These scores are strongly associated with high probability of not regaining function in the arm[1]. Patients who were unable to use their arm before the stroke were excluded. Potential participants were assessed for their ability to consent using the Mental Capacity Act[18]. Those with capacity were asked for their consent to participate. If the potential participant was judged by the researcher not to have capacity to make this decision, a consultee was approached if available. A consultee is someone who knows the person well but is not acting in a professional capacity, who can consider the persons beliefs and provide assent on their behalf if this is in line with their interests[19].

Participants' baseline data were collected at the point of consent and at 3, 6, and 12 months later in the setting of their choice. These time scales allow comparison with previous studies[7,8,9,10]. Throughout the study, all participants received usual care under the UK NHS.

Baseline predictor variables and demographic variables

Five potential predictors of difficulty caring for the arm and related impairments were identified[2]: motor control, mood, sensation/perception, hypertonicity and pain. As the primary outcome related to passive care activities, hand dominance was not considered as a predictor. To maximise inclusivity wherever possible the measures used were suitable for people with aphasia or cognitive impairment. This included using pictographic resources, observational tools and measures with evidence of validity when completed by proxy. The predictor measures are summarised in Table 1[20,21,22,23,24,25,26,27]. Scores for hypertonicity with the Modified Modified Ashworth Scale (MMAS)[22] were applied to the five arm muscles identified as commonly affected (i.e. shoulder adductors and internal rotators, and elbow, wrist and finger flexors)[8]. The single worst score of any muscle group ("*worst hypertonicity*") and the summed score of hypertonicity in all five groups ("*total hypertonicity*") were considered (independently) as predictors. Summary scores of this type have been developed and validated[28].

In addition to these pre-specified predictors, demographic data were also collected including age, sex and type of stroke using the Oxfordshire Community Stroke Project Classification[29].

Outcome measures (3, 6 and 12 months post-stroke)

The primary outcome measure was a scale of difficulty caring for the arm: the Leeds Arm Spasticity Impact Scale[25] (LASIS). This is an item bank of 12 tasks of caring for the arm including aspects of washing, nail-cutting and dressing. The participant rates each relevant task with degree of difficulty using a scale from 0 to 4, and scores are then averaged. Test-retest reliability has been established with a minimally detected change of 0.5[30].

Secondary outcomes included passive range of movement, pain, hypertonicity, active function, and skin integrity. The measures are summarised in Table 1. A protocol for conducting the predictor and outcome measure assessments was developed and demonstrated a good degree of inter-rater reliability, with Kappa scores of 0.82 for MMAS scores, 1.0 for pain, 0.8 for LASIS and 93% agreement for measuring range of movement to within 15 degrees.

Statistical Analysis

All statistical analyses were performed using the statistical programming language R[31]. Summary statistics were produced. Where the data was normally distributed, means and standard deviations were used. Otherwise median and inter-quartile ranges were given. Individual profile plots were constructed to visualise each participant's LASIS average across follow-up points. The linear association between each continuous predictor and LASIS average at 12 months was summarised using Pearson's correlation coefficient, whilst descriptive statistics for LASIS average at 12 months are presented for each level of each categorical predictor.

Multi-variable linear regression was used to identify models of predictors for LASIS average at 12 months post-stroke. For brevity, this paper reports only the overall best fitting model.

Sample size

Sample sizes for multi-variable linear regression are based on the minimum R^2 value of interest and the number of independent predictors. Whilst there were five potential predictors of interest, three are categorical: pain (three categories), sensation/perception (three categories) and hypertonicity (five categories), with two continuous predictors (Fugl-Meyer and mood scores). After recoding categorical predictors as indicator variables, as required for modelling, statistically, it may be considered that there are 10 possible explanatory variables/predictors. Assuming a significance level of 10%, a sample size of 120 participants was required to detect a medium effect size of 0.15 (which corresponds to R^2 value of around 13%) with 90% power. Based on previous studies[32,33], it was estimated that there would be a potential drop off of 10% per measurement session. Therefore, the recruitment target was set

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at 165 participants, with the aim of following-up at least 120 participants at the 12 months post-stroke time point.

Ethics

The study was approved by the NRES South West Ethics Committee (Reference: 11/SW/0149).

Results

Figure 1 illustrates the process of recruitment and follow-up, including reasons for participants lost to follow-up: 833 people were screened for inclusion of which 216 (26%) fulfilled the inclusion criteria, and 155 gave consent or consultee assent to participate (72% of those eligible). At one year 110 participants (71%) were reviewed. Of the remaining 45 participants, 6 declined reassessment, 33 had died and 6 were unavailable.

Participant demographic data at baseline and the predictor measures are summarised in Table 2. The average age of participants was 74.7 years, with a higher proportion of women than men, and almost half of the participants had a total anterior circulation stroke (TACS). At baseline, 82.6% had already developed some hypertonicity, with 17.4% exhibiting pain and 31.8% demonstrating impairment of sensation/perception. Outcome measures at each follow-up are summarised in Table 3 and briefly summarised below.

Longitudinal profiles of difficulty caring for the arm

LASIS outcomes were collected from 104 participants at all time points. The mean LASIS at 3 and 6 months were similar (1.7 and 1.6 respectively) and by 12 months had increased to 2.0. However, there was a large variation in the profiles of each participant's scores, as shown in the individual profile plots in Figure 2, with some showing increasing difficulty over time, some decreasing difficulty and some broader variation. At the 12 month time-point over half (59%) of participants reported no or little difficulty with care tasks but 12%

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reported moderate difficulty and 29% indicated they either had a great deal of difficulty or were unable to perform tasks such as washing or dressing.

Longitudinal profiles of related impairments of body functions and activity limitation

Active function

As anticipated, the majority of participants had not recovered active use of the arm at 12 months, with 73% scoring between 0 and 1 (inclusive) on the Motor activity log (MAL-14) and median values remaining at 0 across time points. However, fifteen participants (14%) regained some use of the arm (scoring two or more on MAL-14). The baseline characteristics of those who regained some use are shown in Table 4.

Hypertonicity

Individual profiles of hypertonicity were very variable over the three time-points, although median hypertonicity total score was 4.0 at all time points (see Table 3). Some participants showed trends for increasing hypertonicity over time, some decreasing and some with no discernible pattern. At one year 77% of survivors had developed some hypertonicity in at least one muscle group (MMAS score at least 1), with severe hypertonicity in at least one muscle group present in 25% of participants (MMAS score at least 3). The muscle groups most commonly affected by severe hypertonicity were elbow and wrist flexors (affecting 14% of participants each), shoulder internal rotators (13%), finger flexors (10%) and shoulder adductors (6%).

Pain

Profiles of pain were also very variable within the group of participants, although a larger proportion reported pain at follow-up compared to baseline, when the vast majority (83%) were pain free. At 12 months, pain in some part of the arm was reported by 65% of participants.

Range of movement

Individual profiles of range of movement were variable over time at all the joints assessed, with some participants having increasing and some decreasing range between 3 and 12 months. However, over the three time points, the mean range of movement, particularly at the shoulder and wrist, was less than would be expected in healthy older adults[34]. Range of movement in the fingers was less reduced. Table 3 includes range for the index finger proximal interphalangeal joint as an example. Other studies have defined contracture as the loss of at least 30% of the available range of movement[17]. Using these criteria, 94% of participants had developed shoulder contracture, 9% elbow contracture, 54% wrist contracture and 7% finger contracture at 1 year.

Skin integrity

Seven participants (6%) developed macerated skin in the hand or elbow-crease at 12 months. None of the participants had broken skin at any point.

Predicting difficulty caring for the arm

Table 5 summarises the bivariate relationships between LASIS average at 12 months and each of the predictors. There was evidence of a positive relationship between the LASIS average and age, hypertonicity total score and mood, although only the linear association between LASIS average and age was statistically significant. We used hypertonicity total scores in the best fitting model because they explained a greater percentage of variance for the LASIS average than worst hypertonicity.

The overall best fitting linear model was derived from the five pre-specified predictors and the four additional baseline variables. After the removal of three outliers, the final model was fitted to data from 106 participants and included age ($p<0.001$), hypertonicity total ($p=0.002$) and stroke classification (participants who have suffered from lacunar stroke (LACS)[29] compared to (a) participants who have suffered from total anterior circulation stroke (TACS)[29] ($p=0.004$) and (b) participants who have suffered from a haemorrhage (p=0.010))(see Table 6). Collectively, these three variables explained approximately one third (adjusted R^2=33%) of the variance in the LASIS average at 12 months. From the linear regression coefficients from this final best fitting model:

- A one year increase in age at baseline increases the LASIS average at 12 months by an average of 0.050 units (standard error (SE) 0.008);
- A one unit increase in hypertonicity total at baseline increases the LASIS average at 12 months by an average of 0.109 units (SE 0.035);
- The mean LASIS average for the group of participants who had suffered from LACS was 0.935 units (SE 0.314) lower than participants who had suffered from TACS and 0.962 units (SE 0.367) lower than the group of participants who had suffered from a haemorrhage.

Discussion

This is the first longitudinal study, to our knowledge, of people with a profoundly-affected arm after stroke. Whilst the sample included a high proportion of people with more severe classifications of stroke this was not surprising given the target population. Many studies restrict recruitment and do not involve people with severe communication or cognitive limitations but we have demonstrated it was possible to include them, by supporting them with enhanced communication resources or using proxies.

Given that participants were those with severe arm weakness at 2-4 weeks post-stroke, observable patterns between impairments and activity limitation were thought to be a possibility. However, this was not the case and longitudinal profiles of these factors were highly individual.

The incidence of impairments in the arm was high when compared to studies that have included general populations of stroke survivors. For example, 77% of our participants who had severe weakness at baseline presented with hypertonicity at one year compared to 49% of those who initially presented with milder weakness at baseline[8]. In addition, 65% of our participants reported pain in the arm compared to 49% of a general population of stroke survivors reporting pain in any part of the body[9]. Incidence of contracture of the shoulder and wrist were also higher than that recorded in general populations of stroke survivors[17], although this was not the case for the elbow. It is unclear why so many of our participants developed loss of range of the shoulder and wrist while the elbow and fingers remained less severely affected. The shoulder is typically held in adduction and internal rotation at rest so may be more vulnerable, while gravity may assist with extension of the elbow. The wrist is a complex joint and contracture of the finger flexor muscle-tendon units may impact on range of movement at the wrist in addition to the fingers. Differences in muscle architecture surrounding connective tissue may also contribute to the variation in contracture between muscles. Recent work in animal studies suggests that there is a direct relationship between muscle atrophy and fibrosis. Cytokine myostatin, for example, is not only central to the pathways that mediate muscle atrophy but can also activate fibroblasts and stimulate fibrosis[35,36]. Thus, differences in the weakness of individual muscles may impact on their relative degree of contracture development and increase in passive stiffness[35,37].

The incidence of difficulty caring for the arm was high, as 29% of participants were either unable to care for their arm or described significant difficulty. A number of predictors of difficulty caring for the arm that can be assessed early after stroke were evaluated. The best linear predictive model based on these included age, hypertonicity and stroke classification, although these factors explained only 33% of the total variability in the LASIS average at one year post-stroke. Our previous review did not identify other impairments that are likely to influence longer-term outcome in caring for the arm[2]. Previous studies have not considered the use of biomarkers as predictors of outcome in this targeted group and it is possible they may add to the predictive value.

There are a number of clinical implications of this work. Whilst recognising that people with profoundly-affected arm gain little from active exercise to improve function[4], given the high incidence of pain, hypertonicity and contracture they may benefit from an educational intervention to reduce the impact of these impairments, and from longer term monitoring. With regard to the important risk factors identified, age and stroke classification cannot be influenced in treatment after stroke but it is possible that early manifestations of hypertonicity can be altered and research could explore if targeting hypertonicity early after stroke can reduce the risk of difficulty caring for the arm longer term, particularly in those with other risk factors.

Study limitations

This study has a number of limitations. Whilst every attempt was made to include measures that had been validated in people with aphasia and cognitive impairment, this was not always possible. The Fugl-Meyer score, in particular, has not been validated in this group. Equally the anticipated sample size of 120 participants at 1 year was not achieved so adequate statistical power may be lacking. Hand dominance was not considered as a predictor variable and this may have an influence in self-care. Finally, no attempt was made to assess the amount or content of rehabilitation that participants received so it is possible that any such interventions may have impacted on outcomes. Therefore conclusions should be drawn with caution.

Conclusions

At one year post-stroke, there was a high incidence of difficulty caring for the arm (measured with LASIS) and of pain, hypertonicity and contracture. Notably, individual profiles were very variable and although some pre-disposing factors have been identified, it remains difficult to predict who is at greatest risk.

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Figure legends:

Figure 1: Flow diagram detailing recruitment and progression of participants

Figure 2 Individual participants LASIS scores at each time point. Each box contains 5 participants in their order of recruitment- where data is missing the participant was lost to follow up.. (N=127 at 3 months, N= 117 at 6 months, N= 111 at 12 months).

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385 **Table 1: Battery of predictor and outcome measures**

Predictors	**Name**	**Scoring**
Motor control	Fugl-Meyer Upper limb score[14]	0-66, higher score indicates better control
Pain	Yes/no response to pain at rest and on passive movement[15]	0,1 or 2, higher score indicates more pain
Hypertonicity	Modified Modified Ashworth scale[16]	0-4, higher score indicates higher tone
Perception/ sensation	Find the thumb test[17]	0,1 or 2, higher score indicates worse perception
Mood	Stroke Aphasic Depression Questionnaire-10[18]	0-30, higher score indicates lower mood
Outcomes		
Difficulty caring for arm	Leeds Arm Spasticity Impact Scale[19]	0-4, higher score indicates more difficulty
Pain	As above	
Hypertonicity	As above	
Passive range of movement	Goniometry of shoulder flexion, abduction, external rotation; elbow flexion, extension; wrist extension, index, little finger and thumb extension at each joint[20]	Range measured in degrees of movement
Skin integrity	Axilla, elbow and hand, classified as dry/ intact; macerated or broken.	0,1 or 2, higher score indicates worse skin condition
Active arm	Motor activity log-14[21]	0-70, higher score indicates better

function		use

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Table 2: Descriptive statistics of participant characteristics and potential predictors at baseline (n=155)

Age	
Mean (SD)	74.7 (12.8)
Range	[38.0, 96.0]
Sex	
Female, n (%)	89 (57%)
Male, n (%)	66 (43%)
Stroke classification	
Not reported, n (%)	1 (0.6%)
Haemorrhage, n (%)	25 (16.2%)
Total anterior circulation stroke, n (%)	73 (47.4%)
Partial anterior circulation stroke, n (%)	30 (19.5%)
Lacunar stroke, n (%)	23 (14.9%)
Posterior circulation stroke, n (%)	3 (1.9%)
Fugl-Meyer upper limb score	
Median [Q1, Q3]	2.0 [2.0, 6.0]
Range	[0.0, 16.0]
Hypertonicity (worse MMAS score)	
0, n (%)	27 (17.4%)
1, n (%)	52 (33.5%)
2, n (%)	53 (34.2%)
3, n (%)	23 (14.8%)
4, n (%)	0 (0%)
Hypertonicity (total score)	

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Median [Q1, Q3]	3.0 [1.0, 5.0]
Range	[0.0, 12.0]
Pain	
No pain at rest or movement, n (%)	128 (82.6%)
Pain on movement only, n (%)	21 (13.5%)
Pain at rest & on movement, n (%)	6 (3.9%)
Mood (SADQ-10)	
Mean (SD)	8.2 (4.5)
Range	[0.0, 23.0]
Sensation/Perception (Find the Thumb test)	
Not reported, n (%)	1 (0.6%)
Able to find affected thumb, n (%)	105 (68.2%)
Able to find affected arm only, n (%)	19 (12.3%)
Unable to find affected arm, n (%)	30 (19.5%)

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392 **Table 3: Descriptive statistics of outcome measures at each follow-up time point**

	3 months n=120	6 months n=113	12 months n=110
LASIS average			
Mean (SD)	1.7 (1.0)	1.6 (1.1)	2.0 (1.3)
Range	[0.08, 4.00]	[0.00, 4.00]	[0.00, 4.00]
Hypertonicity (worse score)			
Not reported, n (%)	2 (1.7%)	4 (3.5%)	1 (0.9%)
0, n (%)	16 (13.6%)	19 (17.4%)	24 (22%)
1, n (%)	31 (26.3%)	33 (30.3%)	29 (26.4%)
2, n (%)	52 (44.1%)	32 (29.4%)	29 (26.4%)
3, n (%)	19 (16.1%)	22 (20.2%)	24 (22%)
4, n (%)	0 (0%)	3 (2.8%)	3 (2.7%)
Hypertonicity (total score)			
Median [Q1, Q3]	4.0 [2.0, 8.0]	4.0 [1.0, 9.0]	4.0 [1.0, 7.8]
Range	[0.0, 15.0]	[0.0, 16.0]	[0.0, 15.0]
Pain			
No pain at rest or movement, n (%)	32 (26.7%)	31 (27.4%)	38 (34.5%)
Pain on movement only, n (%)	60 (50%)	56 (49.6%)	56 (50.9%)
Pain at rest & on movement, n (%)	28 (23.3%)	26 (23.0%)	16 (14.5%)
Passive range shoulder abduction			
Mean (SD)	76.8° (24.4°)	74.3° (22.6°)	79.9° (28.8°)
Range	[25.0°, 170.0°]	[10.0°, 160.0°]	[20.0°, 180.0°]
Passive range shoulder external rotation	22.8° (24.8°)	24.8° (22.7°)	25.0° (27.4°)

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Mean (SD) Range	[-80°, 65.0°]	[-70.0°, 75.0°]	[-60.0°, 90.0°]
Passive range elbow extension Mean (SD) Range	 165.0° (20.0°) [100.0°, 180.0°]	 165.0° (20.8°) [90.0°, 180.0°]	 164.8° (21.0°) [100.0°, 180.0°]
Passive range wrist extension Mean (SD) Range	 38.6° (21.6°) [-60.0°, 90.0°]	 37.7 (26.7°) [-50.0°, 80.0°]	 43.7° (26.6°) [-60.0°, 80.0°]
Passive range index PIP extension Mean (SD) Range	 175.3° (11.5°) [100.0°, 180.0°]	 172.1° (17.3°) [90.0°, 180.0°]	 174.2° (16.3°) [100.0°, 180.0°]
Skin integrity Not reported, n (%) Dry intact, n (%) Macerated, n (%) Broken, n (%)	 0 118 (98.4%) 2 (1.6%) 0	 2 (1.8%) 105 (92.9%) 6 (5.3%) 0	 0 103 (93.6%) 7 (6.4%) 0
Active function (MAL-14) Median [Q1, Q3] Range	 0.0 [0.0, 0.8] [0, 4.21]	 0.1 [0.0, 1.0] [0.0, 5.00]	 0 [0.0, 1.2] [0.0, 4.38]

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Table 4: Descriptive statistics at baseline by functionality at 12 months (n=109)

	Participants with MAL less than two at 12 months (n=94)	Participants with MAL two or greater at 12 months (n=15)
Age		
Mean (SD)	72.7 (12.9)	68.1 (13.7)
Range	[38.0, 95.0]	[40.0, 96.0]
Gender		
Female, n (%)	49 (52%)	9 (60%)
Male, n (%)	45 (48%)	6 (40%)
Stroke classification		
Not reported, n (%)	0 (0%)	0 (0%)
Haemorrhage, n (%)	19 (20.2%)	1 (6.7%)
Total anterior circulation stroke, n (%)	45 (47.9%)	6 (40.0%)
Partial anterior circulation stroke, n (%)	16 (17.0%)	4 (26.7%)
Lacunar stroke, n (%)	12 (12.8%)	4 (26.7%)
Posterior circulation stroke, n (%)	2 (2.1%)	0 (0%)
Fugl-Meyer upper limb scores		
Median [Q1, Q3]	2.0 [2.0, 5.0]	5.0 [4.0, 10.5]
Range	[0.0, 15.0]	[2.0, 15.0]
Hypertonicity (worse MMAS score)		
0, n (%)	16 (17.0%)	3 (20.0%)
1, n (%)	26 (27.7%)	6 (40.0%)
2, n (%)	38 (40.4%)	5 (33.3%)
3, n (%)	14 (14.9%)	1 (6.7%)
4, n (%)	0 (0%)	0 (0%)
Hypertonicity (total score)		
Median [Q1, Q3]	3.0 [1.0, 5.8]	2.0 [1.0, 3.0]
Range	[0.0, 12.0]	[0.0, 7.0]

Pain		
No pain at rest or movement, n (%)	77 (81.9%)	13 (86.7%)
Pain on movement only, n (%)	12 (12.8%)	1 (6.7%)
Pain at rest & on movement, n (%)	5 (5.3%)	1 (6.7%)
Mood (SADQ-10)		
Mean (SD)	8.3 (4.8)	6.1 (4.2)
Range	[0.0, 23.0]	[1.0, 16.0]
Sensation/Perception (Find the Thumb test)		
Not reported, n (%)	1 (1.1%)	0 (0%)
Able to find affected thumb, n (%)	68 (72.3%)	11 (73.3%)
Able to find affected arm only, n (%)	10 (10.6%)	2 (13.3%)
Unable to find affected arm, n (%)	15 (16.0%)	2 (13.3%)

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399 **Table 5: Summary statistics of bivariate relationships between predictors and LASIS**

400 **average at 12 months**

	Mean (SD) [range]	Correlation Coefficient (95% CI)
Age	-	0.39 [0.22, 0.54]
Sex		-
Female	2.2 (1.4) [0.00, 4.00]	
Male	1.7 (1.3) [0.00, 4.00]	
Stroke classification		-
Lacunar stroke (LACS)	1.4 (0.9) [0.00, 3.82]	
Partial anterior circulation stroke (PACS)	1.5 (1.3) [0.09, 4.00]	
Posterior circulation stroke (POCS)	0.9 (0.7) [0.42, 1.44]	
Total anterior circulation stroke (TACS)	2.3 (1.4) [0.00, 4.00]	
Haemorrhage	2.2 (1.3) [0.45, 4.00]	
Fugl-Meyer upper limb score	-	-0.18 [-0.36, 0.01]
Hypertonicity (worse MMAS score)		-
0	1.7 (1.3) [0.27, 4.00]	
1	1.9 (1.4) [0.00, 4.00]	
2	1.9 (1.3) [0.00, 4.00]	
3	2.8 (1.3) [0.55, 4.00]	
4	NA	
Hypertonicity (total score)	-	0.19 [0.00, 0.37]
Pain		-
No pain at rest or movement	1.9 (1.4) [0.00, 4.00]	
Pain on movement only	2.6 (1.3) [0.10, 4.00]	

Pain at rest & on movement	1.7 (0.6) [0.80, 2.27]	
Mood (SADQ-10)	-	0.19 [0.00, 0.36]
Sensation/Perception (Find the Thumb)		-
Able to find affected thumb	1.8 (1.3) [0.00, 4.00]	
Able to find affected arm only	2.3 (1.1) [0.25, 4.00]	
Unable to find affected arm	2.3 (1.5) [0.36, 4.00]	

Table 6: Regression statistics for the overall best fitting model for LASIS average at 12 months

	Coefficient	95% confidence interval	p-value
Intercept	-2.658	[-4.028, -1.288]	<0.001
Age	0.050	[0.034, 0.066]	<0.001
Hypertonicity total	0.109	[0.040, 0.178]	0.002
stroke class POCS	-0.200	[-1.809, 1.409]	0.808
stroke class PACS	0.121	[-0.608, 0.850]	0.744
stroke class TACS	0.935	[0.320, 1.550]	0.004
stroke class HAEM	0.962	[0.243, 1.681]	0.010

Residual standard error: 1.091 on 99 DF
Multiple R-squared: 0.37
Adjusted R-squared: 0.33
F-statistic: 9.6 on 6 and 99 DF, p-value: <0.001

LACS (Lacunar stroke) is the baseline level for stroke classification.

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Figure 1

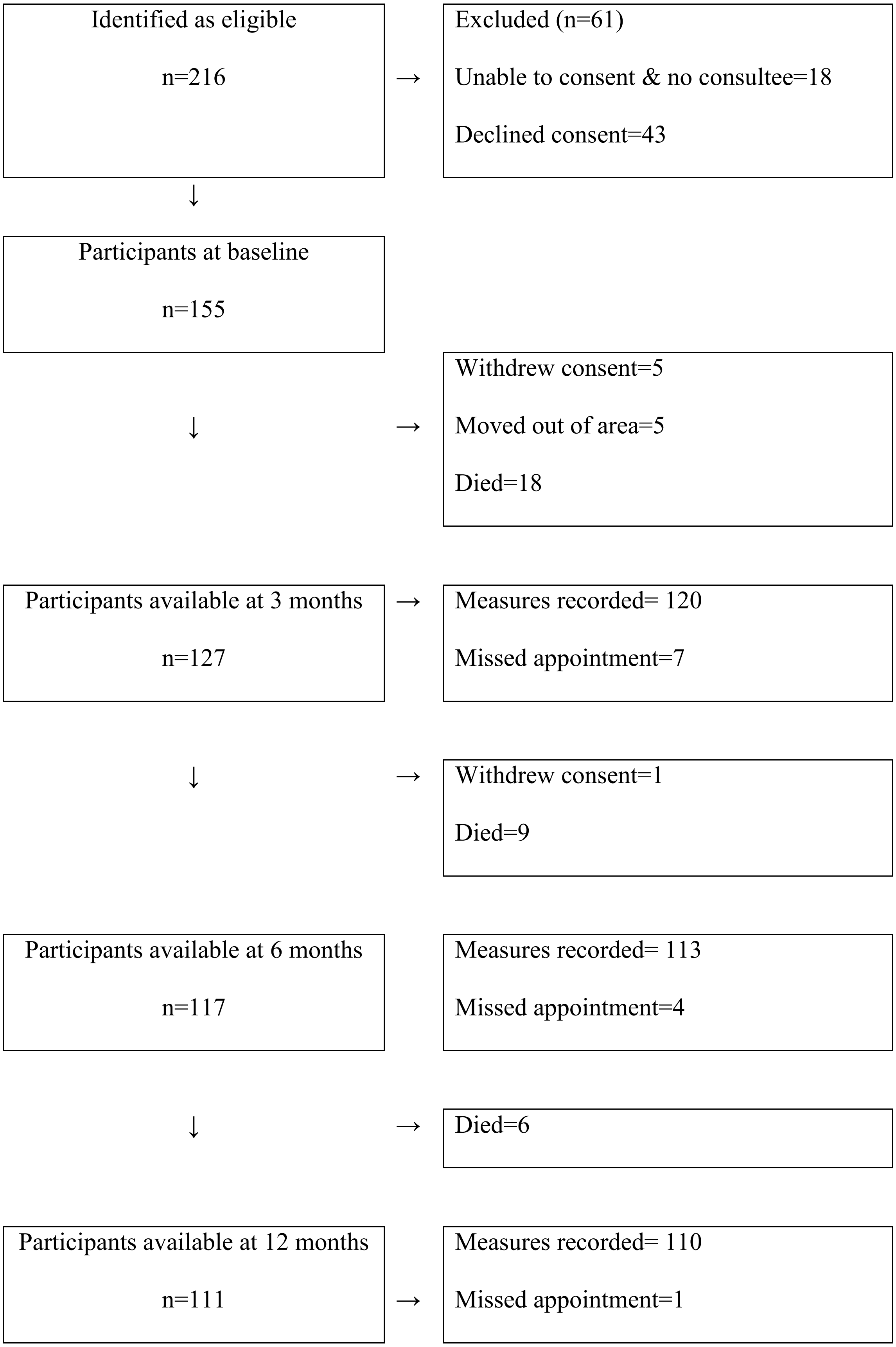

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Figure 2